Solutions

Multiple Choice

1. a
2. c
3. c
4. b
5. d

Problem Solving Questions

Question 1

a)

To see if Dane made it across the gap the car must move more than 30m horizontaly before it falls the 20m vertically. Since we know the horizontal velocity is constant we need to find the time the car is in the air ...

$$\Delta d = v_1 + \frac{1}{2}at^2 \quad \Rightarrow \quad 20 = 0 + \frac{1}{2}(9.8)t^2$$

$$\therefore t = \sqrt{\frac{20(2)}{9.8}} \quad \Rightarrow \quad t = 2.02s$$

Now just convert the car's velocity in m/s and see how far the car travels in 2.02s ...

$$\vec{v} = \frac{58}{3.6} = 16.1\bar{1}m/s$$

$$\therefore \Delta d = 16.1\bar{1}(2.02) = 32.54m$$

The car travelled 32.54m during the 2.02s through the air and therefore made it across the gap.

b)

$\therefore \; F_{g\perp} = 9.8(500)\cos 15 = 4900\cos 15 = 4733.0365\text{N}$
$\therefore \; F_{g\parallel} = 9.8(500)\sin 15 = 4900\sin 15 = 1268.2133\text{N}$

$$\therefore \; F_f = \mu_k F_{g\perp} = 0.6(4733.0365) = 2839.8219\text{N}$$
$$\therefore \; F_{net} = F_f - F_{g\parallel} = 2839.8219 - 1268.2133 = 1571.6086\text{N}$$

Thus the net force in 1571N up the ramp.

$$\because F_{net} = m\vec{a} \quad \Rightarrow \quad F_{net} = 1571.6068 = 500\vec{a} \quad \Rightarrow \quad \vec{a} = 3.143m/s^2$$

We know the initial velocity and the acceleration so we can finally find the time it takes Dane's car to stop ...

$$\vec{v_2} = \vec{v_1} + \vec{a}t$$
$$0 = 25 + (-3.143)t \quad \Rightarrow \quad \frac{-25}{-3.143} = t$$
$$\therefore \; t = 7.6s$$

After landing saftely on the ramp Dane's car took 7.6s to come to a complete stop.

Question 2

a)

In order to solve this problem we need to use the conservation of energy theorem. That is the energy at the top of the hill will be the same as the energy at the bottom of the hill ...

$$E_{top} = E_{potential} + E_{elastic} = mgh + \frac{1}{2}kx^2$$

$$E_{top} = 55(9.8)(35) + \frac{1}{2}(73.4)(5.56)^2$$

*** Remember to change the compression displacement into meters***

$\therefore\ E_{top} = 20000J$

$$E_{bottom} = E_k = \frac{1}{2}mv^2$$

Since Lesley is moving and there elastic or gravitational potential energy.

By the conservation of energy theorem $E_{top} = E_{bottom}$ and thus ...

$$20000 = E_{bottom} = \frac{1}{2}(55)(v^2)$$

$$\sqrt{\frac{40000}{55}} = v \quad \Rightarrow \quad \vec{v} = 26.97m/s$$

Therefore Lesley's speed before the collision is 27m/s.

b)

For an elastic collision kinetic energy as well as momentum are conserved so the momentum equation is as follows ...

$$p_L + p_B = p_L^{'} + p_B^{'}$$

$$m_L v_L + m_B v_B = m_L v_L^{'} + m_B v_B^{'}$$

$$(1)\ \ 55(27) + 0 = 55v_L^{'} + 31v_B^{'}$$

Now the kinetic energy equation is as follows ...

$$\frac{1}{2}m_L{v_L}^2 = \frac{1}{2}m_L{v_L^{'}}^2 + \frac{1}{2}m_B{v_B^{'}}^2$$

$$(2)\ \ 55(27)^2 = 55{v_L^{'}}^2 + 31{v_B^{'}}^2$$

We now have to solve two equation with two unknowns ...

$$(1)\ \ \frac{594 - 55v_L^{'}}{31} = v_B^{'}$$

$$(2)\ \ 40095 = 55{v_L^{'}}^2 + 31(\frac{594 - 55v_L^{'}}{31})$$

$$v_L^{'} = 26.3m/s$$

$$\Rightarrow \quad (1)\ 1485 = 55(26.3039) + 31v_B^{'}$$

$$\therefore \ \ v_B^{'} = 1.24m/s$$

$$\therefore \ \ p_L^{'} = 26.3039(55) = 1450N \cdot s$$

$$\therefore \ \ p_B^{'} = 1.235(31) = 38.285N \cdot s$$

red Therefore, Lesley's momentum was 26.3 $N \cdot s$ to the right. While the second ball's momentum after the collision was $38.3N \cdot s$ also to the right.

Question 3

a)

$$\frac{n_2}{n_1} = \frac{v_1}{v_2} \quad \Rightarrow \quad \frac{n_{glass}}{n_{air}} = \frac{v_{air}}{v_{glass}}$$

$$\frac{1.52}{1.00} = \frac{3.0 \cdot 108}{v_{glass}}$$

$$\therefore \ v_{glass} = \frac{1.00}{1.52}3.0 \cdot 10^8 = 1.97 \cdot 10^8$$

b)

$$\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} \quad \Rightarrow \quad \lambda_2 = \frac{v_2}{v_1}\lambda_1$$

$$\lambda_{glass} = \frac{1.97 \cdot 10^8}{3.0 \cdot 10^8}\lambda_{air}$$

$\lambda_{air} = \frac{v_{air}}{f_{air}} = \frac{3 \cdot 10^8}{6.62 \cdot 10^{14}} = 6.49 \cdot 10^{-7}$

$$\therefore \ \lambda_{glass} = \frac{1.97 \cdot 10^8}{3.0 \cdot 10^8} 6.49 \cdot 10^{-7}$$

$$\therefore \ \lambda_{glass} = 4.26 \cdot 10^{-7} m = 4.26 \cdot 10^2 nm$$

$\therefore$ Percent Change $= \frac{6.49 \cdot 10^{-7} - 4.26 \cdot 10^{-7}}{6.49 \cdot 10^{-7}} = 34.4\%$

Question 4

a)

Her proper length is measured from her frame of reference.

b)

$$L_m = L_s\sqrt{1 - \frac{v^2}{c^2}} \quad \Rightarrow \quad L_s = \frac{L_m}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\therefore \ L_s = \frac{1.5}{\sqrt{1 - \frac{(0.87c)^2}{c^2}}}$$

$$\therefore \ L_s = 3.04m$$

c)

$$t_m = t_s\sqrt{1 - \frac{v^2}{c^2}} \quad \Rightarrow \quad t_s = \frac{t_m}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\therefore\ t_s = \frac{0.5}{\sqrt{1 - \frac{(0.87c)^2}{c^2}}}$$

$$\therefore\ L_s = 1.01s$$

Question 5

Since we want the vertical velocity to zero we can approach this question by the following formula ...

$$v_2 = v_1 + \vec{a}t$$

The final velocity is 0m/s as required and the initial velocity can be found as follows ...

$\sin 37 = \frac{v_y}{\vec{v}}$
$1.5 \cdot 10^5 \sin 37 = v_y$
$\therefore\ v_y = 9.03 \cdot 10^4$

$$\therefore\ 0 = 9.03 \cdot 10^4 + a(1.67)$$

Now the acceleration can be found from $\vec{F} = m\vec{a} \ \Rightarrow\ \vec{a} = \frac{\vec{F}}{m}$. From here the force of the electric field is ...

$$\vec{F} = q\vec{E} \quad \Rightarrow \quad 0 = 9.03 \cdot 10^4 - \frac{q\vec{E}}{m}(1.67)$$

$$\Rightarrow \quad -9.03 \cdot 10^4 = \frac{q\vec{E}}{m}(1.67)$$

$$\Rightarrow \quad \frac{-9.03 \cdot 10^4 m}{-1.67q} = \vec{E}$$

$$\Rightarrow \quad \frac{-9.03 \cdot 10^4(9.11 \cdot 10^{-31})}{-1.60 \cdot 10^{-19}(1.67)} = \vec{E}$$

$$\therefore\ \vec{E} = 3.1 \cdot 10^{-7}$$